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(54) CONTAINER FOR USE IN TREATING LIQUID

(71) We, AGA AKTIEBOLAG, of 181 20 Lidingo 1, Sweden, a Swedish Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a container for use in treatment of liquid, particularly for use in a centrifuge for treating discrete quantities of a liquid by separating it into fractions of different densities and, where desired, by washing solid particles suspended in liquid. The invention has particular application to the centrifugal treatment of blood and the present disclosure will be devoted primarily to this application. It should be understood, however, that the invention is applicable to the treatment of other liquids than blood. It should also be noted that the term "liquid" as used in this specification embraces not only true liquids but also other materials resembling liquids such as the semi-liquid mass of blood cells obtained from whole blood after separation of the plasma.

It is known to treat discrete quantities of blood in a closed system of collapsible containers in a centrifuge rotor. Thus, one container may initially hold a batch consisting of either a mixture of whole blood and a liquid preservative or a suspension of red blood cells in a liquid preservative and a second container may initially hold a quantity of a wash solution while a third container is initially empty. The containers are interconnected through conduits and during the treatment plasma and/or preservative from the first container is passed into the empty third container and temporarily replaced by wash solution from the second container. After agitation of the contents of the first container the used wash solution and the material washed off from the blood cells is passed into the third container leaving the washed red cells in the first container.

The use of collapsible closed containers for the blood, for separated fractions and for wash solution enables the treatment to be carried out under sterile conditions since the containers can be interconnected in a closed system to communicate with each other without their contents coming into contact with the ambient atmosphere or exterior surfaces. The transfer of liquid between the containers has presented problems, however, since the transfer normally has to take place while the centrifuge rotor and the container system rotate at high speed.

In accordance with the present invention, on the other hand, the transfer of liquid can be effected and controlled in a simple and reliable manner.

According to the invention there is provided a container for use in treatment of liquid, particularly in centrifugal separation of liquid into fractions of different densities, the container comprising walls of a flexible sheet material which walls define between them a closed compartment for holding a discrete quantity of liquid, wherein the walls also define between them a conduit having a tubular cross-section which conduit communicates at one end thereof with the liquid compartment.

When the container is used in a centrifuge, a peristaltic pump member which is mounted on the rotor and adapted to rotate with the rotor and the container may be arranged to act continuously on the conduit, and when liquid is to be transferred to or from the liquid compartment, the peristaltic pump member is caused to rotate slowly with respect to the rotor and the container to displace liquid through the conduit. When the peristaltic pump member is stationary with respect to the rotor and the container, it compresses the conduit to block flow therethrough.

As far as the centrifuge used with containers according to this invention is concerned, attention is directed to our co-pending U.K. Patent Application No. 11304/72 (Serial No. 1,373,671) of even date defining its construction.

The invention will be better understood from the following detailed description taken in conjunction with the accompanying diagrammatic drawings.

Fig. 1 is a view in vertical section of the

rotor and associated parts of a centrifuge constructed in accordance with the invention;

Fig. 2 is an enlarged view corresponding to the central portion of Fig. 1;

Fig. 3 is an exploded partly cut away perspective view of the container assembly in the centrifuge shown in Figs. 1 and 2;

Fig. 4 is a plan view of the central portion of the two-compartment container shown in the lower portion of Fig. 3.

The centrifuge diagrammatically illustrated in Fig. 1 has a frame 10 supporting a centrifuge rotor 11 for rotation about a vertical axis at high speed, e.g. 3000 rpm, by means of a motor 12. Rotor 11 includes a bowl 13 having a depending hollow journal member 14 mounted in a ball bearing 15 in frame 10. The rotor bowl and most other elements of the rotor are circular in plan view.

Rotor bowl 13 houses a container assembly the details of which are best seen in Fig. 3. It includes a lower two-compartment container 16 supported on the bottom wall of bowl 13 and an upper single-compartment container 17 supported on top of container 16. Both containers are generally disk shaped and concentric with the rotor bowl. They are both closed, disregarding openings for the introduction and removal of liquid, and made of a thin and flexible sheet material so as to be collapsible. The sheet material may be, for example, a laminate of polyethylene and polyester having a total thickness of about 0.1 millimeter.

Lower container 16 is made of three circular sheets 18, 19, 20 disposed one on the other and sealingly joined along their peripheries by a continuous heat seal 21 and at their central portion by another circular heat seal 22. Lower and central sheets 18, 19 define between them a compartment 23 which initially holds wash solution and central and upper sheets 19, 20 define between them a compartment 24 which is initially empty.

In the central portion of container 16, heat seals 25 (marked by closely spaced dash lines in Fig. 4) joining sheets 18, 19 define a collapsible conduit 26 through which wash solution in compartment 23 can flow to a short connecting tube 27 secured to upper sheet 20 around an opening 28 in the latter via an opening 31 in sheet 19 (see also Fig. 2). Similar heat seals 29 (marked by closely spaced full lines in Fig. 4) joining sheets 19, 20 define another collapsible conduit 30 through which liquid can flow from connecting tube 27 to compartment 24. Portions of conduits 26, 30 extend along two concentric circles and cooperate with a pump 32 described in more detail hereinafter. This pump is operable to produce the liquid flow and to block the conduits when flow is not desired. Heat seal 22 prevents liquid in the two compartments from entering the central container portion except through the conduits.

Upper container 17 initially holds a quantity of blood cells suspended in a liquid preservative. It consists of two sheets 33, 34 which are joined by a heat seal 35 at their peripheries and a heat seal 36 at their central portions so that they define between them an annular compartment. A connecting tube 37 communicates with this compartment through a conduit 38 defined by heat seals. An opening 39 in the central portion permits tube 37 to be connected with tube 27 of container 16.

Conduits 26 and 30 as well as conduit 38, owing to the characteristics of the material and the manner in which they have been produced, have a strong natural tendency to close themselves. Thus, in order that they may permit the liquid in the containers to pass through them, the liquid must be subjected to a substantial pressure. Therefore, no special precautions are necessary to prevent unwanted flow through the conduits during manual handling of the containers.

Referring again to Fig. 1, a filler ring 40 and a backing plate 41 are disposed between containers 16 and 17. Connecting tube 27 extends through an opening in the backing plate and is connected to connecting tube 37.

Rotor 11 includes a cover assembly with a rigid cover plate 42 which has an internally screw-threaded boss 43 and holds an annular body 44 made of soft rubber mixed with lead granules so as to have higher specific gravity than the liquids in the containers. A clamping mechanism having an externally screw-threaded sleeve 45 screwed into boss 43 and a number of circumferentially distributed wedges 46 connected to the sleeve through rods 47 cooperates with cover plate 42 and bowl 13 to hold down the cover assembly against the containers. A photoelectric detector 48 mounted in sleeve 45 signals the presence of red blood cells in connecting tube 37.

Pump 32 referred to above is of the well-known peristaltic type which has a plurality of rollers moved in a circular path to progressively collapse a resilient conduit so as to displace liquid in the conduit. It has two concentric and independently movable circular groups of rollers, each comprising three rollers spaced apart 120°. The outer group of rollers 49 are rotatably mounted on an outer rotor member 50 secured to a hollow shaft 51 which is concentric with rotor 1. These rollers cooperate with conduit 26. The inner group of rollers 52 are rotatably mounted on an inner rotor member 53 secured to a shaft 54 extending coaxially through shaft 51. These rollers cooperate with conduit 30.

As best seen in Fig. 2, rollers 49 and 52

engage conduits 26 and 30 through a flexible diaphragm 55 to locally compress and close these conduits against backing plate 41.

Rotor members 50 and 53 normally are stationary with respect to the rotating centrifuge rotor and the containers but when desired they can be slowly rotated with respect to the centrifuge rotor during rotation of the latter. Positive rotational movement of rotor member 50 is derived from journal member 14 of rotor bowl 13 by means of a gear 56 engaging a gear on the journal member and another gear 57 engaging a gear on hollow shaft 51. Gears 56 and 57 are mounted for rotation about a common axis but normally there is no driving connection between them. However, a magnetic clutch 58 can be actuated to cause these gears to rotate in unison so as to bring about slow rotation of rotor member 50 with respect to container 16 (clockwise as seen from above in Figs. 1, 2 and in Fig. 4). Similarly, positive rotational movement of rotor member 53 (anti-clockwise) is derived from journal member 14 through gears 59, 60 and a clutch 61.

The procedure for the treatment of the blood cells in container 17 will now be described. Rotor 11 is assumed to be stationary but assembled as shown in Fig. 1, although compartment 24 of container 16 is empty so that sheets 19 and 20 engage each other face to face under the influence of pressure from rubber body 44. Thus, the peripheral portions of the containers are clamped between the bottom of bowl 13 and filler ring 40 and between the latter and rubber body 44. The central portions of the containers are clamped between the rollers of pump 32 and the lower end of boss 43 of cover plate 42. The rubber body in conjunction with the shape of the parts ensure that unwanted air pockets adjacent the containers are virtually eliminated.

Rotor 11 is then caused to rotate with clutches 58, 61 disengaged so that pump rotor members 50, 53 rotate in unison with the centrifuge rotor owing to the friction between these rotor members and diaphragm 55 and other parts of the centrifuge rotor. Under the influence of the centrifugal forces, the heavy soft rubber of body 44 is forced outwardly to apply an external pressure to containers 16, 17. Owing to the arrangement and shape of the parts, this pressure forces the liquid in the containers inwardly and causes conduits 26, 30 to assume the expanded form shown in Fig. 2. However, since the rollers of the rotor members are stationary with respect to the rotor and the containers and compress the conduits, no liquid is permitted to pass through the latter.

The centrifugal field, which may be of the order of 1000 g, causes the formation of fractions of different densities in container 17, that is, the red blood cells accumulate in the radially outer portion of container 17 while the lighter preservative liquid is collected in the radially inner portion. Clutch 61 is then engaged to cause inner rotor member 53 to rotate anticlockwise (Fig. 4) with respect to the centrifuge rotor and the containers so that the preservative liquid is pumped from container 17 into compartment 24 of container 16 through conduit 38, connecting tubes 37, 27 and conduit 30. Since outer rotor member 50 is still stationary with respect to the centrifuge rotor and the containers, the preservative liquid is prevented from flowing through conduit 26.

When detector 48 signals the presence of red blood cells in tube 37, clutch 61 is again disengaged and clutch 58 engaged so that outer rotor member 50 is caused to rotate to pump wash solution from compartment 23 into container 17 through conduit 26, tubes 27, 37 and conduit 38 while inner rotor member 53 is held stationary to prevent flow through conduit 30. When a sufficient amount of wash solution has been transferred, clutch 58 is disengaged so that both conduits 26, 30 are closed whereupon rotor 11 is rapidly braked (by means not shown) to low speed to agitate the contents of container 17 and thoroughly mix the wash solution and blood cells.

The wash solution is then separated from the blood cells and transferred to compartment 24 of container 16 in the same manner as has been described for the preservative liquid. The washing step described above is repeated as many times as necessary and when the treatment is completed, container 17 contains a concentrate of washed blood cells while container 16 contains liquid preservative and used wash solution in compartment 24. Compartment 23 may be empty or contain a residue of wash solution.

It will be appreciated that the two-compartment container with its integral conduits offers significant advantages from a manufacturing as well as from a handling point of view.

WHAT WE CLAIM IS:—

1. A container for use in treatment of liquid, particularly in centrifugal separation of liquid into fractions of different densities, the container comprising walls of a flexible sheet material which walls define between them a closed compartment for holding a discrete quantity of liquid, wherein the walls also define between them a conduit having a tubular cross-section which conduit communicates at one end thereof with the liquid compartment.

2. A container according to claim 1, wherein the liquid compartment is of generally annular shape, and wherein the conduit is located in the central portion of the container radially inwardly of the inner margin of the liquid compartment.

3. A container according to claim 1 or 2, wherein the conduit is defined by heat seals joining the walls.

4. A container according to any one of claims 1 to 3, wherein a connecting tube is attachable to one of the walls and when attached communicates with the conduit.

5. A container according to claim 1, wherein the walls are generally circular and include an upper wall, a central wall and a lower wall, wherein the upper and central walls define between them a first generally annular compartment and a first conduit communicating at one end thereof with the first compartment and at the other end with a connecting tube secured to the upper wall, wherein the central and lower walls define between them a second generally annular compartment and a second conduit communicating at one end thereof with the second compartment and at the other end with the connecting tube, and wherein portions of the first and second conduits extend along respective ones of two concentric circles.

6. A container for use in treating liquid, constructed, arranged, and adapted to operate substantially as herein described with reference to the accompanying drawings.

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

Fig.1

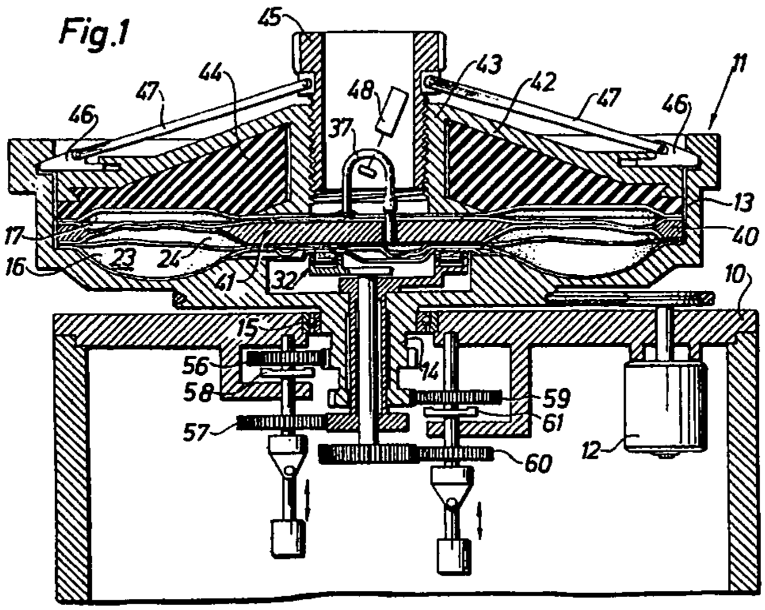

Fig.2

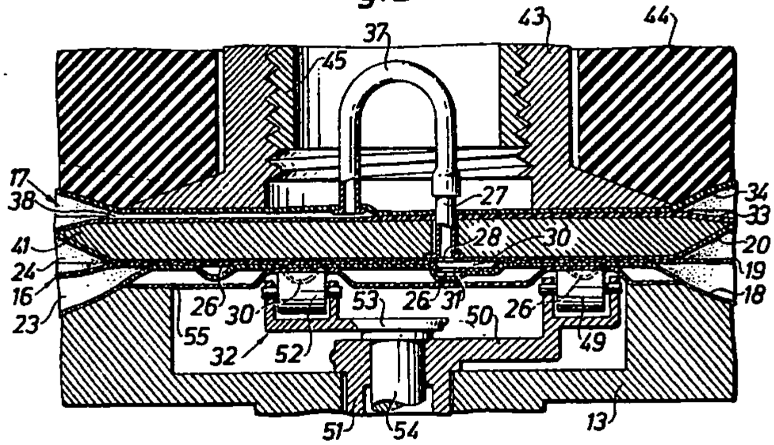

Fig.3

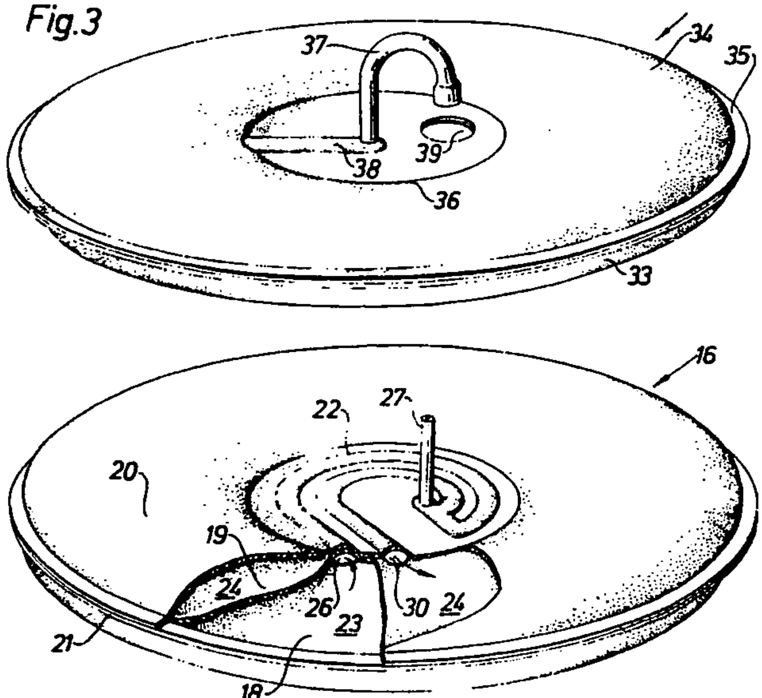
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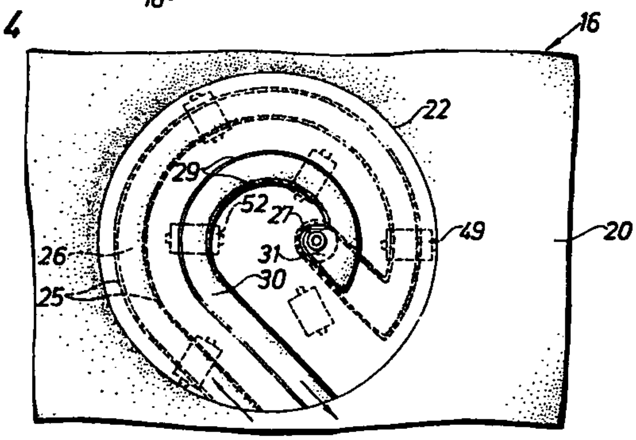
Fig.4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